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THE PURPOSE OF THIS STUDY WAS TO CONDUCT AN ASSESSMENT OF INTERIM RESPONSE ACTIONS (IRA) THAT COULD 1) REDUCE EXPOSURE OF THE POPULATION TO POTENTIALLY CONTAMINATED GROUND WATER AND 2) MITIGATE GROUND WATER CONTAMINANT MIGRATION NORTH OF RMA. THE ASSESSMENT FOCUSED ON EVALUATING ACTIONS THAT WOULD, IN ADDITION TO THE PRESENT PROGRAM OF MONITORING AND SUPPLYING AN ALTERNATE WATER SUPPLY, BEGIN TO CONTROL MIGRATION BEFORE LONG-TERM ACTIONS ARE IMPLEMENTED.

FOR THIS STUDY, A PRELIMINARY LIST OF INTERIM RESPONSE GOALS WAS DEVELOPED TO DEFINE CLEANUP LEVELS.

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CONTAMINANTS LOCATION, TREATMENT, COST

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LITIGATION TECHNICAL SUPPORT AND SERVICES

ROCKY MOUNTAIN ARSENAL

OFFPOST REMEDIAL INVESTIGATION/FEASIBILITY STUDY

FINAL OFFPOST INTERIM ACTION ASSESSMENT REPORT
JULY 1987
CONTRACT NUMBER DAAK11-84-D-0016
TASK NUMBER 39

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

US ARMY
PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

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LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Offpost Remedial Investigation/Feasibility Study

Offpost Interim Action Assessment Report

July 1987

Contract Number DAAK11-84-D-0016

Task Number 39

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

OFFICE OF THE PROGRAM MANAGER

ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP

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1.0 INTRODUCTION

The purpose of this study was to conduct an assessment of interim response actions that could reduce exposure of the population to potentially contaminated ground water and mitigate ground water contaminant migration north of the Rocky Mountain Arsenal (RMA). The assessment focused on evaluating actions that would, in addition to the present program of monitoring and supplying an alternate water supply, begin to control migration of offpost ground water contamination in areas known to be contaminated by RMA-specific compounds before long-term actions are implemented.

In most cases, the technologies that were utilized in this study are technologies currently being employed at RMA. The large database on the effectiveness and cost of these technologies allows for realistic cost-effectiveness evaluations. Although more cost-effective methods for ground water treatment may exist, introduction of these technologies would generally require pilot testing which is beyond the scope of the interim action assessment.

Applicable data on contaminant levels, contaminant locations, and appropriate ground water quality criteria were compiled. For this study, a preliminary list of guidance levels to be used as interim response objectives were developed. Based upon the types and concentration of contaminants and upon the estimated quantity of contaminated water, several options for contamination and exposure mitigation were identified for evaluation.

The costs for each alternative are only approximate and were estimated to provide a basis of comparison between alternatives. The effectiveness of each alternative was defined as its ability to reduce exposure and/or reliability to mitigate the contamination in the study area. The relative effectiveness of each option was evaluated by identifying its advantages and disadvantages compared to the other alternatives.

This report should be utilized to evaluate the advantages, disadvantages, and approximate costs of implementing interim response actions offpost of RMA for contaminants known to have originated from RMA. As the offpost Remedial Investigation (RI) and Feasibility Study (FS) associated with Task 39 proceeds, assessments of offpost contamination will be refined and long-term contamination mitigation alternatives will be identified, screened, and evaluated. An important consideration in the evaluation and selection of interim actions is the compatibility of near-term interim actions with the potential long-term final remedial actions. In order to assure that the recommended interim actions are compatible with long-term actions, those organizations planning and implementing the interim action should work closely with the persons responsible for the Task 39 RI/FS. This interaction is explained in Section 4.0.

2.0 CONTAMINANT IDENTIFICATION AND LOCATION

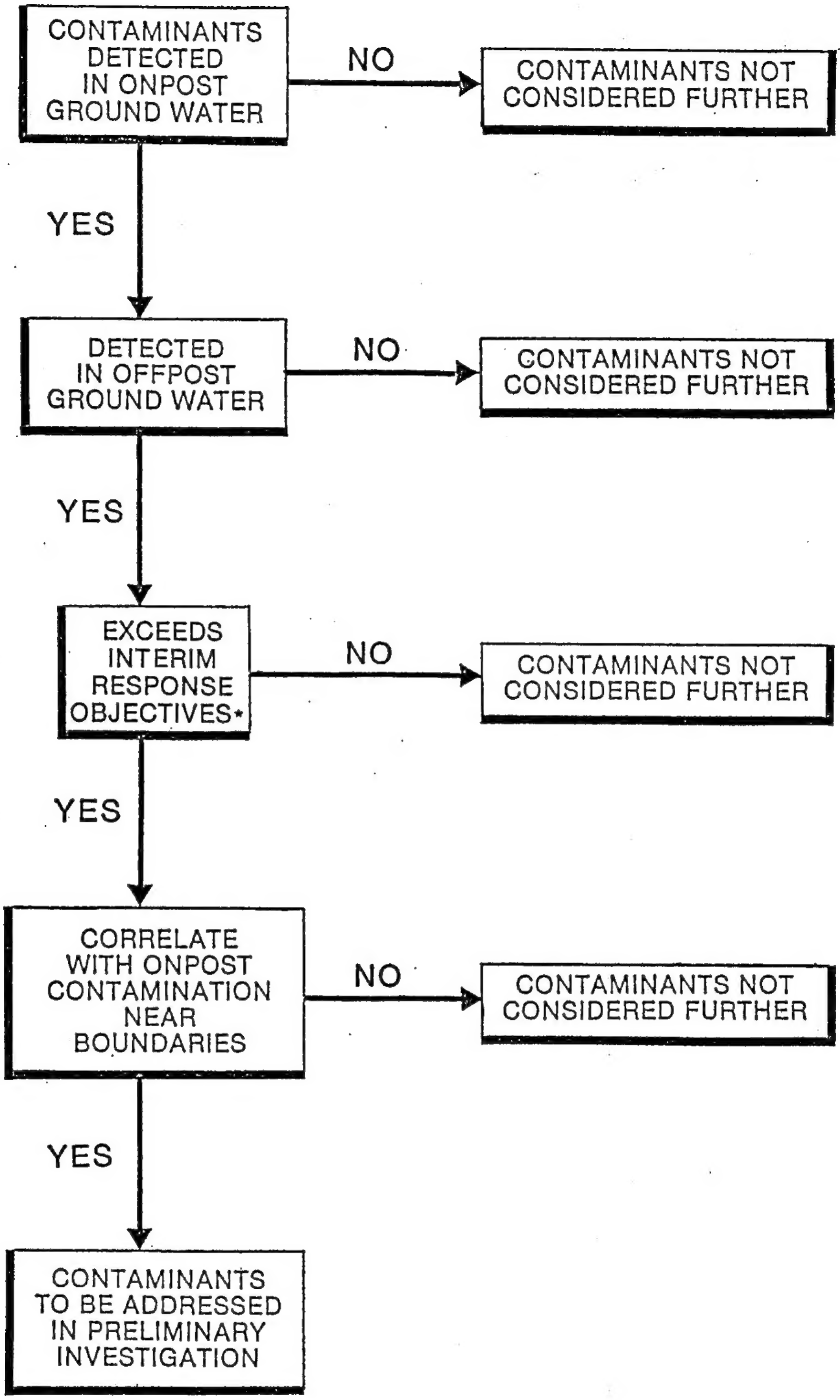
An evaluation of offpost analytical data was performed to determine areas of contamination, and define the study area. The study area was delineated by offpost wells showing RMA-specific contamination above the proposed RMA criteria. The data that were used in the evaluation included five quarters of data from the Revision III 360° and Task 44 sampling programs, Consumptive Use (CU) Phase I and II Programs, and selected historical 360° sampling results. The selected historical 360° data were from the wells that were sampled in both the historical and Revision III 360° Programs.

The "Contaminants of Concern" for this study were identified from a screening process illustrated in Figure 2.0-1. Contaminants detected offpost were compared with the proposed RMA criteria or interim response objectives (Table 2.0-1). Contaminants exceeding these objectives were mapped to identify possible contaminant migration pathways and areas to be addressed. The procedure for identifying "Contaminants of Concern" at RMA included the following criteria:

- o Contaminants that have been observed in ground water or surface water on RMA and near the north or northwest boundaries;
- o Contaminants exhibiting a spatial pattern of contamination similar to contaminants documented to have migrated across the boundary; and
- o Contaminants found offpost which have been documented to have been associated with RMA onpost activities.

Utilizing these criteria, the final list of "Contaminants of Concern" were determined and are shown in Table 2.0-2.

Based upon the distribution of these "Contaminants of Concern", nearly all RMA-specific compounds above the response objectives, were confined to the study area shown in Figure 2.0-2. The study area for the interim action assessment has been confined to a zone north and northwest of the RMA north boundary and southeast of O'Brian Canal. Although there have been isolated detections of contaminants outside this area, RMA-specific contaminants have



* SEE TABLE 2.0-1

Figure 2.0-1
SCREENING CONTAMINANTS OF CONCERN

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

TABLE 2.0-1 (Page 1 of 3)
DETECTION LIMITS, GUIDANCE LEVELS AND INTERIM RESPONSE OBJECTIVES

CONTAMINANTS	DETECTION LIMIT (ug/l)	‡‡ GUIDANCE LEVEL (ug/l)	+INTERIM RESPONSE OBJECTIVES (ug/l)
‡ALDRIN	0.07	0.07	0.31
ENDRIN	0.05	0.2	0.2
‡DIELDRIN	0.06	0.06	0.12
‡ISODRIN	0.06	0.06	2.5
HEXACHLOROCYCLOPENTADIENE (HCCPD)	0.07	1.0	1.0
‡pp-DICHLORODIPHENYLETHENE (pp-DDE)	0.05	0.05	10
‡pp-DICHLORODIPHENYLTRICHLOROETHANE pp-DDT	0.07	0.07	10
DICYCLOPENTADIENE (DCPD)	9.31	24	24.0
‡METHYLISOBUTYLKETONE (MIBK)	NV	NV	1,750
‡DIBROMOCHLOROPROPANE (DBCP)	0.13	0.2	2.5
‡DISSOPROPYLMETHYLPHOSPHONATE (DIMP)	10	500	26,300
‡DIMETHYLMETHYLPHOSPHONATE (DMMP)	15	7000	1,090
‡p-CHLOROPHENYLMETHYLSULFONE (PCPMSO2)	4.7	4.7	200
‡p-CHLOROPHENYLMETHYLSULFOXIDE (PCPMSO)	4.2	4.2	220
‡p-CHLOROPHENYLMETHYSULFIDE (PCPMS)	1.3	1.3	200
‡DIMETHYL DISULFIDE (DMDS)	1.8	1.8	NV
‡1,4-DITHIANE	2.0	2.0	700
‡1,4-OXATHIANE	25	25	1,050
‡TOLUENE	1.2	14.3	3,000
BENZENE	1.3	5.0	5.0

TABLE 2.0-1 Continued (Page 2 of 3)
DETECTION LIMITS, GUIDANCE LEVELS AND INTERIM RESPONSE OBJECTIVES

CONTAMINANTS	DETECTION LIMIT (ug/l)	** GUIDANCE LEVEL (ug/l)	+INTERIM RESPONSE OBJECTIVES (ug/l)
*XYLENE		440	350
m-XYLENE	1.35		
o,p-XYLENE	2.47		
*CHLOROBENZENE	0.58	488	20
*CHLOROFORM (CHCL3)	1.4	1.9	40
CARBON TETRACHLORIDE	2.4	5.0	5.0
*trans-1,2-DICHLOROETHENE	1.2	70.0	350
TRICHLOROETHENE	1.1	5.0	5.0
*TETRACHLOROETHENE	1.3	8	70
*METHYLENE CHLORIDE (CH2CL2)	5.0	5.0	4.7
1,1-DICHLOROETHYLENE	1.1	7.0	7.0
1,2-DICHLOROETHANE	0.61	5.0	5.0
1,1,1-TRICHLOROETHANE	1.7	200	200
*1,1-DICHLOROETHANE	1.2	1.2	4,000
*1,1,2-TRICHLOROETHANE	1.0	1.0	60
*ETHYLBENZENE	1.3	680	300
CHLORIDE	4,800	250,000	250,000
*FLUORIDE	1,200	2,400	2,800
*SULFATE	10,000	250,000	1,700,000
*NITRATE & NITRITE	10.0	10,000	4,000
*CALCIUM	500	NV	170,000
*MAGNESIUM	500	NV	32,000
*POTASSIUM	1260	NV	3,700
*SODIUM	763	NV	140,000

TABLE 2.0-1 Continued (Page 3 of 3)
DETECTION LIMITS, GUIDANCE LEVELS AND INTERIM RESPONSE OBJECTIVES

CONTAMINANTS	DETECTION LIMIT (ug/l)	** GUIDANCE LEVEL (ug/l) ++	+INTERIM RESPONSE OBJECTIVES (ug/l)
*ARSENIC (TOTAL) (As)	3.9	50 100	5
*CADMIUM (TOTAL) (Cd)	5.2	10 10	5
CHROMIUM (TOTAL) (Cr)	6.0	50 100	50
COPPER (TOTAL) (Cu)	7.9	1,000 200	200
*LEAD (TOTAL) (Pb)	18.5	50 100	20
MERCURY (TOTAL) (Hg)	0.2	2.0	2.0
ZINC (TOTAL) (Zn)	20.1	5,000 2,000	2,000

* DENOTES DIFFERENCE BETWEEN GUIDANCE LEVELS AND CRITERIA
** PRELIMINARY GUIDANCE LEVELS WERE DEVELOPED AND USED IN PREVIOUS OFFPOST STUDIES.
\+ APPENDIX A - RESPONSE OBJECTIVES FOR INTERIM ACTION; RE: OFFPOST GROUND WATER CONTAMINATION.
++ FIRST VALUE CORRESPONDS TO DOMESTIC SUPPLY AND SECOND VALUE CORRESPONDS TO AGRICULTURE
NV DENOTES NO VALUE GIVEN

TABLE 2.0-2 (Page 1 of 3)
CONTAMINANTS OF CONCERN

CONTAMINANTS DETECTED IN ONPOST GROUND WATER	CONTAMINANTS DETECTED IN OFFPOST GROUND WATER	CONTAMINANTS EXCEEDING INTERIM RESPONSE OBJECTIVES	CONTAMINANTS OF CONCERN
ALDRIN	ALDRIN	ALDRIN	** HEALTH BASED **
ENDRIN	ENDRIN	ENDRIN	ALDRIN
DIELDRIN	DIELDRIN	DIELDRIN	ENDRIN
ISODRIN	ISODRIN	DCPD	DIELDRIN
HCCPD	HCCPD	DBCP	DBCP
pp-DDE	pp-DDE	BENZENE	BENZENE
pp-DDT	pp-DDT		
DCPD	DCPD		
MIBK	MIBK		
DBCP	DBCP		** ORGANOLEPTIC BASED **
DIMP	DIMP		DCPD
DMMP	PCPMSO2		
PCPMSO2	PCPMSO		
PCPMSO	PCPMS		
PCPMS	DMDS		
DMDS	1,4-DITHIANE		
1,4-DITHIANE	1,4-OXATHIANE		
1,4-OXATHIANE	TOLUENE		
TOLUENE	BENZENE		
BENZENE			

TABLE 2.0-2 Continued (Page 2 of 3)
CONTAMINANTS OF CONCERN

CONTAMINANTS DETECTED IN ONPOST GROUND WATER	CONTAMINANTS DETECTED IN OFFPOST GROUND WATER	CONTAMINANTS EXCEEDING INTERIM RESPONSE OBJECTIVES	CONTAMINANTS OF CONCERN
XYLENE	CHLOROBENZENE	CHCL3	** HEALTH BASED **
m-XYLENE			
o,p-XYLENE	CHCL3	CARBON TETRACHLORIDE	CHCL3
CHLOROBENZENE	CARBON TETRACHLORIDE	TRICHLOROETHENE	CARBON TETRACHLORIDE
CHCL3	trans-1,2-DICHLOROETHENE	TETRACHLOROETHENE	TRICHLOROETHENE
CARBON TETRACHLORIDE	TRICHLOROETHENE	CH2CL2	TETRACHLOROETHENE
trans-1,2-DICHLOROETHENE	TETRACHLOROETHENE	1,2-DICHLOROETHANE	CH2CL2
TRICHLOROETHENE	CH2CL2	CHLORIDE	1,2-DICHLOROETHANE
TETRACHLOROETHENE	1,1-DICHLOROETHYLENE	FLUORIDE	1,1,2-TRICHLOROETHANE
CH2CL2	1,2-DICHLOROETHANE	SULFATE	FLUORIDE
1,1-DICHLOROETHYLENE	1,1,1-TRICHLOROETHANE	NITRATE	SULFATE
1,2-DICHLOROETHANE	1,1-DICHLOROETHANE	CALCIUM	NITRATE
1,1,1-TRICHLOROETHANE	1,1,2-TRICHLOROETHANE	MAGNESIUM	SODIUM
1,1-DICHLOROETHANE	ETHYLBENZENE	POTASSIUM	
1,1,2-TRICHLOROETHANE	CHLORIDE	SODIUM	** ORGANOLEPTIC BASED **
ETHYLBENZENE	FLUORIDE		CHLORIDE
CHLORIDE	SULFATE		CALCIUM
FLUORIDE	NITRATE		MAGNESIUM
SULFATE	CALCIUM		POTASSIUM
NITRATE	MAGNESIUM		
CALCIUM	POTASSIUM		
MAGNESIUM	SODIUM		
POTASSIUM			
SODIUM			

TABLE 2.0-2 Continued (Page 3 of 3)
CONTAMINANTS OF CONCERN

CONTAMINANTS DETECTED IN ONPOST GROUND WATER	CONTAMINANTS DETECTED IN OFFPOST GROUND WATER	CONTAMINANTS EXCEEDING INTERIM RESPONSE OBJECTIVES	CONTAMINANTS OF CONCERN
As (TOTAL)	As (TOTAL)	As (TOTAL)	** HEALTH BASED **
Cd (TOTAL)	Cd (TOTAL)	Cd (TOTAL)	As (TOTAL)
Cr (TOTAL)	Cr (TOTAL)		Cd (TOTAL)
Cu (TOTAL)	Cu (TOTAL)		
Pb (TOTAL)	Pb (TOTAL)		
Hg (TOTAL)	Zn (TOTAL)		** ORGANOLEPTIC BASED **
Zn (TOTAL)			

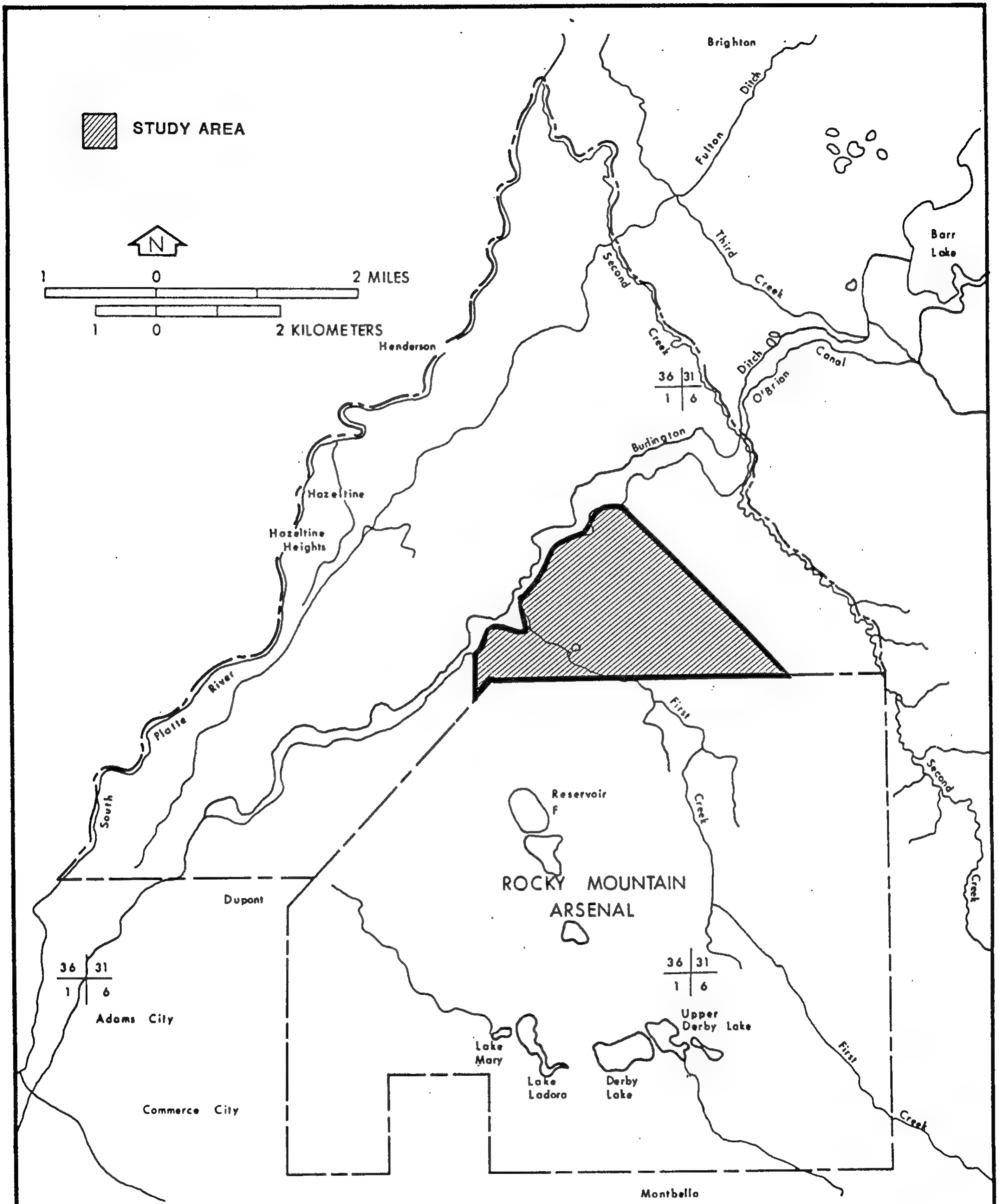


Figure 2.0-2
STUDY AREA FOR THE INTERIM ACTION ASSESSMENT

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U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

generally not been detected outside this area above the response objectives proposed for the offpost RI/FS.

Contamination at the northwest boundary has generally been confined to areas immediately adjacent to the Northwest Boundary Treatment System (NWBTS). Ongoing monitoring has shown no indication that RMA-specific compounds are moving substantially downgradient of the RMA boundary. Therefore, the area northwest of the NWBTS will not be addressed in this study. However, the monitoring system in this area is being supplemented and the water quality routinely evaluated to identify any changes.

The study area also corresponds to routine detections of other contaminants which are not necessarily attributable to RMA. Although several of these other contaminants have been detected downgradient of the study area, these detections have generally been sporadic and could be attributable to other sources. The majority of offpost contamination was addressed by focusing on the study area shown in Figure 2.0-2.

Based upon existing data, a single potential migration pathway for ground water contamination offpost of RMA was identified as requiring interim action. The pathway corresponds to an inferred bedrock surface paleochannel that runs from the north boundary of RMA northwest along First Creek. Several RMA-specific contaminants, as well as other contaminants, have been detected above response objectives along this pathway. Detection of RMA-specific contaminants along this pathway that are above the proposed response objectives, have been confined to the area southeast of O'Brian Canal. This area was identified in the RMA Offpost Assessment, Contamination Assessment Report (ESE, 1986).

3.0 DEVELOPMENT OF ALTERNATIVES

Three control strategies that were used in developing complete response alternatives are presented in Sections 3.1 and 3.2. The control strategies include:

- o Ground water monitoring and alternate water supplies;
- o Dewatering and construction of a new offpost treatment system; and
- o Dewatering and modification of existing treatment facilities.

Either individually or in conjunction with other strategies, these strategies were used to develop discrete interim response action alternatives. Section 3.3 contains a description of six alternatives that may be appropriate to mitigate exposure and control migration of contaminants.

3.1 GROUND WATER MONITORING AND ALTERNATE WATER SUPPLY

The first control strategy is a program which delineates areas of contamination, and identifies and monitors populations that may potentially be exposed to contaminants. Alternate water will be supplied to the exposed populations. This course of action has been pursued in offpost areas during the last several years under the CU Phase I, II, and III programs. To evaluate the cost of a representative monitoring program, the cost per sample associated with the CU Phase I program was used. The cost for a representative program was based upon quarterly sampling and analysis for all CU Phase I wells within the study area (approximately 19 wells) and annual sampling and analysis of the remaining CU Phase I wells (approximately 97 wells).

Two types of alternate water supplies were considered for this strategy. The first, bottled water, would be available to all exposed populations at minimal costs. The second type of alternate water supply would be individual supply wells which would be installed for each exposed household. These wells would have sufficient capacity [approximately 5 to 10 gallons per minute (gpm)] to supply all domestic water needs for showering, drinking, gardening or other routine uses.

In order to develop the costs for the alternate water supplies, an estimate of approximately 16 households and 48 people was used. This estimate is quite conservative in that it includes all households in the study area that do not presently have an alternate water source and several households which are located immediately downgradient of the study area.

3.2 TREATMENT CONTROL STRATEGIES

In order to develop treatment strategies that would effectively address contaminated ground water in the study area, an estimate of ground water flow was needed. Based upon hydrogeologic and water quality data, an appropriate estimate for this assessment was obtained by evaluating a dewatering scheme for the alluvial aquifer just upgradient of O'Brian Canal in the vicinity shown in Figure 3.2-1. The natural flow for the alluvial aquifer in this area was estimated, at a maximum, to be 230 gpm. This estimate is only approximate due to the absence of aquifer data in the study area. The flow rate was increased by 30 percent to account for uncertainties in the approximation. The resultant conceptual design flow that was used to develop treatment alternatives was 300 gpm.

3.2.1 New Treatment System

The second type of control strategy is construction of a new dewatering, treatment, and recharge system that would be used to treat and recharge ground water withdrawn from the alluvial aquifer. The cost for this alternative was based upon the conceptual design flow rate of 300 gpm and the treatment of both organic and inorganic contaminants. The cost estimates were based upon an activated carbon system for organics and ion exchange system for inorganics. The dewatering system as shown in Figure 3.2-1 would address the alluvial pathway. A single, offpost treatment system was evaluated to treat flows from this pathway. Because of the uncertainty of land values and procurement costs for property in the offpost study area, the cost for a site to house the treatment facility was not included in the capital cost for this strategy. The actual amount of property required for the new treatment system would be less than an eighth of an acre.

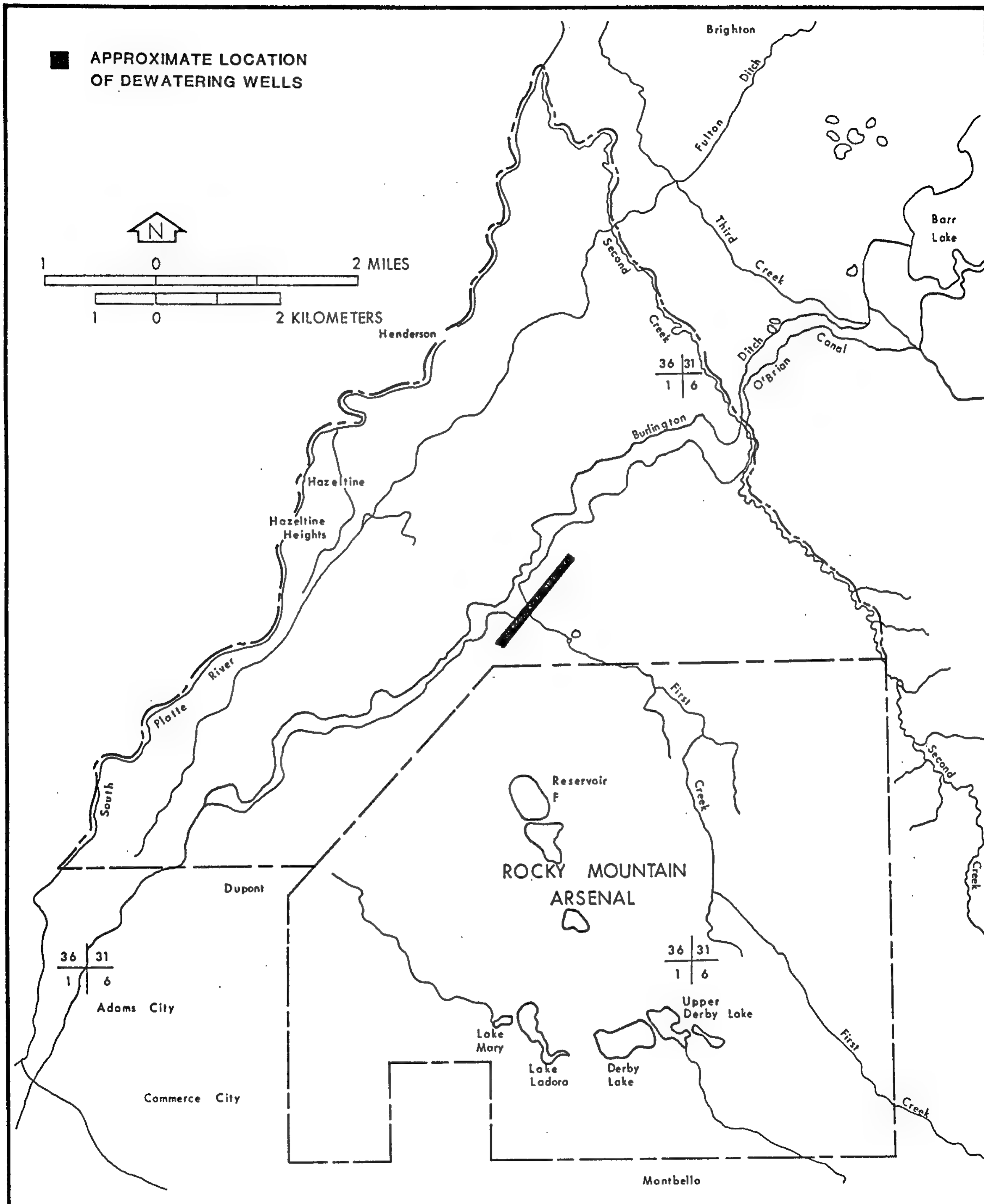

Figure 3.2-1
CONCEPTUAL DEWATERING AREAS

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For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

3.2.2 Modified North Boundary Treatment System

The third control strategy involves offpost dewatering of design flows, transfer of water to the North Boundary Treatment System (NBTS), and modification of this system to handle additional flows and contaminants. This would result in a total design flow of 700 gpm based upon a present capacity at the NBTS of 400 gpm (Mizoue, 1986). Modifications to the NBTS included additional carbon treatment, an ion exchange system to treat inorganics, and additional recharge wells.

3.3 ALTERNATIVES

The three control strategies outlined in the previous sections were assembled into six discrete alternatives. These alternatives are:

- A. Ground water monitoring and provision of bottled water;
- B. Ground water monitoring and provision of Arapahoe wells;
- C. Ground water monitoring, provision of bottled water, and an offpost withdrawal, treatment and recharge system;
- D. Ground water monitoring, provision of Arapahoe wells, and an offpost withdrawal, treatment, and recharge system;
- E. Ground water monitoring, provision of bottled water, and an offpost dewatering system with treatment and recharge at the NBTS; and
- F. Ground water monitoring, provision of Arapahoe wells, and an offpost dewatering system with treatment and recharge at the NBTS.

The capital costs and operation and maintenance costs for each alternative are shown in Tables 3.3-1 through 3.3-6. The monitoring program was considered essential for all alternatives to evaluate the extent of offpost contamination and identify exposed populations. A cost for continued ground water monitoring was therefore included in each alternative.

The cost associated with supplying an alternate water source was also deemed essential for all alternatives to minimize exposure of populations in the study area. A conservative estimate of the total number of households and people in the study area was used to approximate the cost of these actions.

TABLE 3.3-1

A. MONITORING PROGRAM, ALTERNATE WATER (BOTTLED WATER)
1986 DOLLARS

	*** CAPITAL COSTS ***	*** ANNUAL O & M ***
MONITORING PROGRAM (QUARTERLY SAMPLING OF 19 WELLS AND ANNUAL SAMPLING OF 97 WELLS)	$0	$688,000
BOTTLED WATER (THREE QT PER PERSON PER DAY, 16 HOUSEHOLDS & 48 PEOPLE)	$1,000	$13,000
* TOTAL *	$1,000	$701,000

TABLE 3.3-2

B. MONITORING PROGRAM, ALTERNATE WATER (ARAPAHOE WELLS)
1986 DOLLARS

	*** CAPITAL COSTS ***	*** ANNUAL O & M ***
MONITORING PROGRAM (QUARTERLY SAMPLING OF 19 WELLS AND ANNUAL SAMPLING OF 97 WELLS)	$0	$688,000
ARAPAHOE WELLS (ONE PER HOUSEHOLD, 16 HOUSEHOLDS)	$864,000	$0
PUMP REPLACEMENT (5 YR)	$0	$2,000
POWER	$0	$4,000
* TOTAL *	$864,000	$694,000

TABLE 3.3-3

C. MONITORING PROGRAM, ALTERNATE WATER (BOTTLED WATER), AND AN OFFPOST WITHDRAWAL, TREATMENT, AND RECHARGE SYSTEM.
(300 GPM OFFPOST TREATMENT FACILITY)
1986 DOLLARS

	*** CAPITAL COSTS ***	*** ANNUAL O & M ***
MONITORING PROGRAM (QUARTERLY SAMPLING OF 19 WELLS AND ANNUAL SAMPLING OF 97 WELLS)	$0	$688,000
BOTTLED WATER (THREE QT PER PERSON PER DAY, 16 HOUSEHOLDS & 48 PEOPLE)	$1,000	$13,000
WITHDRAWAL		
20 DEWATERING WELLS	$278,000	$0
DEWATERING PIPING & PUMPS	$33,000	$0
ANNUAL DEWATERING COSTS	$0	$36,000
PUMP REPLACEMENT	$0	$4,000
TREATMENT		
ION EXCHANGE	$151,000	$27,000
ACTIVATED CARBON TREATMENT	$658,000	$202,000
RECHARGE		
25 RECHARGE WELLS	$382,000	$0
PIPING AND PUMPS	$45,000	$0
ANNUAL RECHARGE COSTS	$0	$73,000
RECHARGE PUMPING (OPERATION)	$0	$5,000
RECHARGE PUMP REPLACEMENT	$0	$1,000
* TOTAL *	$1,548,000	$1,049,000

TABLE 3.3-4

D. MONITORING PROGRAM, ALTERNATE WATER (ARAPAHOE WELLS),AND AN OFFPOST WITHDRAWAL, TREATMENT, AND RECHARGE SYSTEM.
(300 GPM OFFPOST TREATMENT FACILITY)
1986 DOLLARS

	*** CAPITAL COSTS ***	*** ANNUAL O & M ***
MONITORING PROGRAM (QUARTERLY SAMPLING OF 19 WELLS AND ANNUAL SAMPLING OF 97 WELLS)	$0	$688,000
ARAPAHOE WELLS (ONE PER HOUSEHOLD, 16 HOUSEHOLDS)	$864,000	$0
PUMP REPLACEMENT (5 YR)	$0	$2,000
POWER	$0	$4,000
WITHDRAWAL		
20 DEWATERING WELLS	$278,000	$0
DEWATERING PIPING & PUMPS	$33,000	$0
ANNUAL DEWATERING COSTS	$0	$36,000
PUMP REPLACEMENT	$0	$4,000
TREATMENT		
ION EXCHANGE	$151,000	$27,000
ACTIVATED CARBON TREATMENT	$658,000	$202,000
RECHARGE		
25 RECHARGE WELLS	$382,000	$0
PIPING AND PUMPS	$45,000	$0
ANNUAL RECHARGE COSTS	$0	$73,000
RECHARGE PUMPING (OPERATION)	$0	$5,000
RECHARGE PUMP REPLACEMENT	$0	$1,000
* TOTAL *	$2,411,000	$1,042,000

TABLE 3.3-5

E. MONITORING PROGRAM, ALTERNATE WATER (BOTTLED WATER), OFFPOST WITHDRAWAL, TRANSMISSION TO NBTS, TREATMENT AND RECHARGE.
(700 GPM MODIFIED NORTH BOUNDARY TREATMENT SYSTEM)
1986 DOLLARS

	*** CAPITAL COSTS ***	*** ANNUAL O & M ***
MONITORING PROGRAM (QUARTERLY SAMPLING OF 19 WELLS AND ANNUAL SAMPLING OF 97 WELLS)	$0	$688,000
BOTTLED WATER (THREE QT PER PERSON PER DAY, 16 HOUSEHOLDS & 48 PEOPLE)	$1,000	$13,000
WITHDRAWAL		
20 DEWATERING WELLS	$278,000	$0
DEWATERING PIPING & PUMPS	$33,000	$0
ANNUAL DEWATERING COSTS	$0	$36,000
PUMP REPLACEMENT	$0	$4,000
TRANSMISSION PIPING TO NBTS (4000'-300 GPM)	$35,000	$6,000
TREATMENT		
ION EXCHANGE	$318,000	$57,000
ACTIVATED CARBON TREATMENT	$463,000	$202,000
RECHARGE		
33 RECHARGE WELLS	$510,000	$0
PIPING AND PUMPS	$59,000	$0
ANNUAL RECHARGE COSTS	$0	$97,000
RECHARGE PUMPING (OPERATION)	$0	$7,000
RECHARGE PUMP REPLACEMENT	$0	$1,000
* TOTAL *	$1,697,000	$1,111,000

TABLE 3.3-6

F. MONITORING PROGRAM, ALTERNATE WATER (ARAPAHOE WELLS), OFFPOST WITHDRAWAL, TRANSMISSION TO NBTS, TREATMENT AND RECHARGE.
(700 GPM MODIFIED NORTH BOUNDARY TREATMENT SYSTEM)
1986 DOLLARS

	*** CAPITAL COSTS ***	*** ANNUAL O & M ***
MONITORING PROGRAM	$0	$688,000
(QUARTERLY SAMPLING OF 19 WELLS AND ANNUAL SAMPLING OF 97 WELLS)		
ARAPAHOE WELLS	$864,000	$0
(ONE PER HOUSEHOLD, 16 HOUSEHOLDS)		
PUMP REPLACEMENT (5 YR)	$0	$2,000
POWER	$0	$4,000
WITHDRAWAL		
20 DEWATERING WELLS	$278,000	$0
DEWATERING PIPING & PUMPS	$33,000	$0
ANNUAL DEWATERING COSTS	$0	$36,000
PUMP REPLACEMENT	$0	$4,000
TRANSMISSION PIPING TO NBTS	$35,000	$6,000
(4000'-300 GPM)		
TREATMENT		
ION EXCHANGE	$318,000	$57,000
ACTIVATED CARBON TREATMENT	$463,000	$202,000
RECHARGE		
33 RECHARGE WELLS	$510,000	$0
PIPING AND PUMPS	$59,000	$0
ANNUAL RECHARGE COSTS	$0	$97,000
RECHARGE PUMPING (OPERATION)	$0	$7,000
RECHARGE PUMP REPLACEMENT	$0	$1,000
* TOTAL *	$2,560,000	$1,104,000

4.0 EVALUATION OF ALTERNATIVES

4.1 ALTERNATIVES ASSESSMENT

Table 4.1-1 summarizes the costs and relative advantages and disadvantages for the six interim response action alternatives assembled for this study. As indicated, continued monitoring and provision of alternate water supply would be the least expensive alternatives but neither alternative would provide for interim contamination mitigation measures. In addition, supplying bottled water would not eliminate hazards associated with other domestic uses such as showering. Individual water supply wells would mitigate risks associated with domestic water usage but would not be adequate for irrigation and consumption by livestock.

Alternatives C through F have the distinct advantage of providing interim measures that would monitor ground water quality and provide alternate water as well as withdraw, treat and recharge ground water in the contaminated zone delineated by the study area. These alternatives were based upon proven technologies and, if implemented correctly, would minimize further migration of contaminants. In particular, these systems would begin to treat contaminated ground water in the interim before a long-term system is implemented and would retard further downgradient migration of contaminants in the primary alluvial pathways. Activated carbon systems have a proven record of effectively treating the majority of organic contaminants found at RMA. These systems would require little testing to achieve adequate results considering the lower overall concentrations of contaminants offpost.

There are, however, several economic and technical disadvantages which should be considered before interim treatment actions are undertaken. The capital cost for the withdrawal, treatment, and recharge systems would be approximately $1,547,000 and $1,696,000 for the new system and modified NBTS, respectively. Annual operation and maintenance costs are estimated to be $348,000 and $410,000, respectively. These are significant expenditures when considering that contaminant pathways are still not well defined offpost and that interim dewatering schemes might not ensure complete capture of contaminated ground water flows.

TABLE 4.0-1 (Page 1 of 3)

SUMMARY OF INTERIM ACTION ASSESSMENT

	PRELIMINARY ALTERNATIVE DESCRIPTION	ADVANTAGES	DISADVANTAGES	CAPITAL COST	ANNUAL O&M
A.	MONITORING PROGRAM, ALTERNATE WATER (BOTTLED WATER)	1. Identifies specific offpost contaminants. 2. Eliminates exposure to population from drinking water. 3. Relatively inexpensive. 4. Will not affect regional ground water before detailed studies are complete.	1. Does not take steps to mitigate contamination offpost in interim before long term action implementation. 2. Only addresses exposure associated with drinking water (i.e. does not address other domestic usage: irrigation, consumption by livestock, etc.)	$1,000	$701,000
B.	MONITORING PROGRAM, ALTERNATE WATER (ARAPAHOE WELLS)	1. Identifies specific offpost areas at exposure. 2. Eliminates exposure to population from all domestic water usage. 3. Relatively inexpensive. 4. Will not effect regional ground water in aquifers that are presently being studied.	1. Does not take steps to mitigate contamination offpost in interim before long term action implementation. 2. Effects of dewatering of Arapahoe are not well defined. 3. May not be sufficient water supply for irrigation and livestock requirements.	$864,000	$694,000
C.	MONITORING PROGRAM, ALTERNATE WATER (BOTTLED WATER), AND AN OFFPOST WITHDRAWAL, TREATMENT AND RECHARGE SYSTEM. (300 GPM OFFPOST TREATMENT FACILITY)	1. Identifies specific offpost areas at exposure. 2. Eliminates exposure to population from drinking water. 3. Proven treatment technology. 4. Should reduce organic and inorganic contaminant levels offpost in interim before long term action implementation. 5. Should minimize further down-gradient migration of contaminants.	1. Only addresses exposure associated with drinking water (i.e. does not address other domestic usage: irrigation, consumption by livestock, etc.) 2. May not be most cost effective treatment strategy (i.e. combination of air stripping and carbon or in-situ treatment, etc.)* 3. May exacerbate existing hydraulic conditions at the North Boundary. 4. Offpost withdrawal and recharge would effect regional ground water patterns and could invalidate present hydrogeologic studies. 5. Offpost contaminant distributions are not defined well enough to ensure complete capture by dewatering. 6. Relatively expensive.	$1,548,000	$1,049,000

* Pilot testing is required for other technologies.

TABLE 4.0-1 Continued (Page 2 of 3)

SUMMARY OF INTERIM ACTION ASSESSMENT

	PRELIMINARY ALTERNATIVE DESCRIPTION	ADVANTAGES	DISADVANTAGES	CAPITAL COST	ANNUAL O&M
D.	MONITORING PROGRAM, ALTERNATE WATER (ARAPAHOE WELLS), AND AN OFFPOST WITHDRAWAL, TREATMENT AND RECHARGE SYSTEM. (300 GPM OFFPOST TREATMENT FACILITY)	1. Identifies specific offpost areas at exposure. 2. Eliminates exposure to population from all domestic water usage. 3. Proven treatment technology. 4. Should reduce organic and inorganic contaminant levels offpost in interim before long term action implementation. 5. Should minimize further down-gradient migration of contaminants.	1. Effects of extensive dewatering of Arapahoe are not well defined. 2. May not be sufficient water supply for irrigation and livestock requirements. 3. May not be most cost effective treatment strategy (i.e. combination of air stripping and carbon or in-situ treatment, etc.)* 4. May exacerbate existing hydraulic conditions at the North Boundary. 5. Offpost withdrawal and recharge would effect regional ground water patterns and could invalidate present hydrogeologic studies. 6. Offpost contaminant distributions are not defined well enough to ensure complete capture by dewatering. 7. Relatively expensive.	$2,411,000	$1,042,000
E.	MONITORING PROGRAM, ALTERNATE WATER (BOTTLED WATER), OFFPOST WITHDRAWAL, TRANSMISSION TO NTBS, TREATMENT AND RECHARGE. (700 GPM MODIFIED NORTH BOUNDARY TREATMENT SYSTEM)	1. Identifies specific offpost areas at exposure. 2. Eliminates exposure to population from drinking water. 3. Proven treatment technology. 4. Should reduce organic and inorganic contaminant levels offpost in interim before long term action implementation. 5. Addresses all inorganic contaminants at North Boundary. (i.e. Inorganic contaminants are not treated at North Boundary presently.) 6. Should minimize further down-gradient migration of contaminants.	1. Only addresses exposure associated with drinking water (i.e. does not address other domestic usage: livestock, etc.) 2. May not be most cost effective treatment strategy (i.e. combination of air stripping and carbon or in-situ treatment, etc.)* 3. May exacerbate existing hydraulic conditions at the North Boundary. 4. Offpost contaminant distributions are not defined well enough to ensure complete capture by dewatering. 5. May exacerbate existing recharge problems at North Boundary. 6. Offpost withdrawal and recharge at North Boundary would effect regional ground water patterns and could invalidate present hydrogeologic studies. 7. Must transport contaminated water over considerable distances to get back to North Boundary. 8. Relatively Expensive.	$1,697,000	$1,111,000

* Pilot testing is required for other technologies.

TABLE 4.0-1 Continued (Page 3 Of 3)

SUMMARY OF INTERIM ACTION ASSESSMENT

	PRELIMINARY ALTERNATIVE DESCRIPTION	ADVANTAGES	DISADVANTAGES	CAPITAL COST	ANNUAL O&M
F.	MONITORING PROGRAM, ALTERNATE WATER (ARAPAHOE WELLS), OFFPOST WITHDRAWAL, TRANSMISSION TO NTBS, TREATMENT AND RECHARGE. (700 GPM MODIFIED NORTH BOUNDARY TREATMENT SYSTEM)	1. Identifies specific offpost areas at exposure. 2. Eliminates exposure to population from all domestic water usage. 3. Proven treatment technology. 4. Should reduce organic and inorganic contaminant levels offpost in interim before long term action implementation. 5. Addresses all inorganic contaminants at North Boundary. (i.e. Inorganic contaminants are not treated at North Boundary presently.) 6. Should minimize further down-gradient migration of contaminants.	1. Effects of extensive dewatering of Arapahoe are not well defined. 2. May not be sufficient water supply for irrigation and livestock requirements. 3. May not be most cost effective treatment strategy (i.e. combination of air stripping and carbon or in-situ treatment, etc.)* 4. May exacerbate existing hydraulic conditions at the North Boundary. 5. Offpost contaminant distributions are not defined well enough to ensure complete capture by dewatering. 6. May exacerbate existing recharge problems at North Boundary. 7. Offpost withdrawal and recharge at North Boundary would effect regional ground water patterns and could invalidate present hydrogeologic studies. 8. Must transport contaminated water over considerable distances to get back to North Boundary. 9. Relatively Expensive.	$2,560,000	$1,104,000

* Pilot testing is required for other technologies.

In addition to the substantial capital, operation, and maintenance costs, an interim treatment system is not necessary to mitigate exposure to offpost populations in the interim. From a technical standpoint, implementation of an interim offpost system may alter offpost ground water patterns and invalidate hydrogeologic studies being performed for the long-term FS. These systems would not necessarily be completely compatible with the long-term cleanup program selected.

It is also probable that more effective treatment strategies such as air stripping in series with activated carbon and/or in situ treatment may be more appropriate for the offpost area. For example, little or not recent data has been obtained on the volatile organic content of the NBTS effluent. Verification of chloroform concentrations in NBTS effluent will be achieved in Task 25 which will analyze NBTS effluent water for all volatile organics. If the results of Task 25 show that the NBTS is not adequately treating chloroform, an air stripping unit or other applicable technology could possibly be required to supplement an offpost carbon system that is similar to the NBTS. In addition, ground water treatment technology is evolving rapidly. If other technologies are deemed more cost-effective in the long-term FS, there is no assurance that the interim systems could be completely utilized in the long-term cleanup program.

4.2 RECOMMENDED INTERIM ACTION

In order to assure the public health and the environment will be properly protected before the long-term remedial action is selected, installed and operating, an interim action should be considered. The interim actions proposed in this assessment cover a wide range of alternatives which differ in degrees of protection and differ in financial expenditures. At a minimum, the interim action should consider monitoring and supply of alternate water. This strategy is contained in all six options. However, only those options which withdraw, treat, and re-inject ground water will provide for environmental protection by controlling contaminated ground water migration. For this reason, the interim action should be the most cost-effective

treatment alternative. As shown in Table 4.1-1, Alternative C provides clean water to potentially exposed persons as well as controls migration of RMA contaminants at a low relative cost. At this time, Alternative C appears to be the most cost-effective interim action.

Prior to implementation of this action, the organization, in this case it will most likely be the U.S. Corps of Engineers (COE), should work with the offpost RI/FS team to assure that this interim action is truly the most cost-effective alternative and that it is compatible with the long-term remediation that is recommended. From an operational standpoint, the COE representative or contractor should come up to speed as soon as possible and should become involved in the RI/FS through to selection of a long-term remedial action in Spring 1988. If the proposed interim action is not compatible with the long-term action, the interim action should be modified appropriately and detailed design and installation should commence by Summer 1988. The interim action should be maintained and operated until which time the long-term remedial action is in place and is providing beneficial results.

REFERENCES

Environmental Science and Engineering, Inc. (ESE). 1987. RIC#87012R77. Rocky Mountain Arsenal Offpost Assessment Contamination Assessment Report. Vol. I and II. Englewood, Colorado.

Mizoue, J.Y. (ESE). November 25, 1986. Personal Communication with R. Sweder (RMA-North Boundary Treatment Center).

Tucker, W.A. (ESE). April 10, 1987. Personal Communication with Z.A. Smith (ESE).

APPENDIX A
RESPONSE OBJECTIVES FOR INTERIM ACTION
RE: OFFPOST GROUND WATER CONTAMINATION

Response Objectives for Interim Action
Re: OffPost Groundwater Contamination

The overriding objectives of potential interim action to control groundwater contamination in the RMA offpost area are to:

1) reduce further migration of contaminated groundwater into less contaminated areas;

2) accelerate groundwater restoration in areas where the presence of RMA migrating contaminants is well documented; and

3) reduce human exposure to potentially hazardous concentrations of pollutants.

As will be discussed below, human exposure to groundwater contaminants in the off post study area is minimal at this time due to low population density, and the use of alternative uncontaminated water sources for domestic consumption. Consequently the first two objectives above will be the most important consideration in the evaluation, selection, and design of potential interim actions. The remainder of this discussion, however, will focus on objective (3) as a basis for defining numerical contaminant-specific ground water quality objectives. These objectives will guide the interim action alternatives analysis by defining the areal extent of alluvial groundwater that may require an interim response, and effluent quality objectives for a groundwater treatment system.

Insofar as the proposed interim action is only part of a total remedial action that will ultimately meet the requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 as amended by PL 99-499, October 17, 1986, the interim action is not required to attain applicable or relevant and appropriate requirements (ARARs)

pursuant to section 121(d) (4) (A) of said statute. Nonetheless it may be inefficient, in the long run, to implement an interim action in a portion of the site that is inconsistent with the requirements of the final remedial action. For this reason, it is appropriate to establish ARAR's as goals for the interim response. It is also appropriate to establish goals for the interim action that assure protection of human health, considering that the interim action will only affect exposure during the period after implementation of the interim action, but before implementation of the final action. This period will be referred to as the effective period of the interim action.

The Department of Justice, based on guidance provided by the U.S. Environmental Protection Agency, has determined the ARARs for the RMA-migrating contaminants in the offpost ground water, as documented in Appendix A. The following section presents the results of a comprehensive review of the toxicity of contaminants associated with RMA which are being monitored in offpost groundwater for the offpost RI. Factors other than toxicity were also considered as the basis for establishing groundwater quality restoration objectives. These latter considerations include taste and odor (organoleptic effects), non-health based state and federal standards, criteria and guidance levels, and naturally-occurring background levels of the contaminants. These data are integrated in a systematic fashion to:

1) determine whether achieving the ARAR's will assure protection of public health during the effective period of the interim action; and

2) develop interim response objectives for contaminants for which ARARs have not been established.

The first step is an evaluation of the most recent and reliable toxicological assessments for the subject contaminants, relying principally on U.S. EPA and U.S. Army sources. These sources were used

to identify an acceptable chronic intake, or acceptable dose, in units of mg/kg/day; this parameter is labeled D_t. For carcinogens, D_t is defined as the dose which, with a 95% confidence, will not impose greater than a 10^{-6} lifetime individual carcinogenic risk. Assuming the consumption of 2 L of water per day over a 70-year period as the only exposure route and a 70-kg average adult body weight, health-based ground water criteria may be calculated based on the D_t value. Criteria are presented for individual carcinogenic risks ranging from 10^{-4} to 10^{-7}. In conducting this solely health-based assessment, sources of toxicological information were prioritized in the event that alternative sources indicated conflicting information. The prioritized list of sources is presented as Table 1.

The basis for prioritizing information sources included:

1. relevance to ground water used as drinking water supply,
2. the extent to which the source is based on a review of the most recent toxicological information, and
3. the extent to which the source of information provides guidance on toxicological effects resulting from low level exposures.

The first six sources listed in Table 1 have been subjected to peer review within EPA and external public comment. Sources 9, 10, and 11 were used only for those contaminants which are not documented in sources 1 through 8.

For several compounds, EPA-documented values are not available, requiring that criteria be derived on the basis of laboratory research presented in journal articles or other informational sources. Guidelines are available concerning the application of appropriate safety factors or uncertainty factors to the daily intake values calculated on the basis of laboratory results. As recommended by EPA (1980; 1985a), a safety factor of 1,000 was used to account for the uncertainty associated with extrapolating from a subchronic LOEL value based on animal data to a

human risk protection value. Where the daily intake value was derived based on an LD_{50} value from an animal study, a safety factor of 10^5 was applied as described by Layton et al. (1986). These factors were used to ensure that human exposure to these compounds is kept to levels protective of human health.

The second step in this evaluation was to review criteria in terms of considerations other than human health effects. The values in the National Interim Primary (and Secondary) Drinking Water Standards (NIPDWS and NISDWS) and Maximum Contaminant Levels (MCLs) are based on elements in addition to health including technical feasibility and cost and, in the case of NISDWS values, on non-health-threatening effects such as the mottling of teeth following exposure to high fluoride levels. Three other sources of information which were considered under this heading are RMA-specific agreements with the State of Colorado Department of Health (CDH), CDH standards for agricultural water uses, and organoleptic (taste and odor) criteria. When considering taste and odor criteria, it was necessary to discern whether they represented standards or threshold values. The latter description implies that the value represents the limit of detection and, therefore, does not represent a nuisance. It is recommended that a value designated as a threshold be multiplied by a factor of three to set a concentration at which the nuisance value is sufficient to warrant declaring the water nonpotable for humans. In the description for some of the compounds, the organoleptic value is referred to as one which "will control undesirable taste and odor quality" and is, therefore, set as an objective.

The third step was to consider the ARARs developed by the Department of Justice, as documented in Appendix A.

The fourth step resulted in recommendations for the interim response objectives which are presented in the last column of Table 2. Five considerations controlled the selection of a numerical response objective:

1. the criterion must meet or exceed the ARAR;
2. the response objective must be protective of human health;
3. for carcinogens, the cancer risk must be within the acceptable risk range established by EPA policy, i.e., less than or equal to 10^{-4};
4. it is infeasible to achieve a criterion less than background; and
5. a detection limit may not be considered as background.

Further discussion and clarification is warranted with respect to the third consideration listed above. First and foremost, it is emphasized that permitting levels of contaminants associated with a 10^{-4} risk for lifetime exposure as a criterion for the interim action does not imply that individuals in the area have a 10^{-4} incremental risk of death from cancer as a result of exposure to that contamination. The water is not currently used as a drinking water supply, so, exposure to ground water contaminants is negligible at this time.

The potential for future use of a presently unused aquifer is a heavily weighted factor in decisions regarding a final action which seeks a permanent solution. Decisions regarding an interim action can be more substantially affected by water use plans over a reasonable planning horizon.

To assure protection of human health from exposure to carcinogenic contaminants, the duration of exposure becomes a critical consideration. Currently accepted carcinogenic risk assessment methods are based on the assumption that cancer risk is proportional to total lifetime exposure (i.e. exposure rate x 70 years of exposure). A corollary to this assumption is that a higher exposure rate over a period shorter than 70 years could result in the same risk as a lower exposure rate over the full lifetime. The effective period of the interim action thus affects the determination of an acceptable level of carcinogenic contaminants in

ground water. Clearly this consideration is only appropriate if it can be assumed that the final remedial action will result in exposure rates that are adequately protective over the 70-year lifetime.

Thus, both exposure rate and exposure duration are important considerations in a carcinogenic risk assessment. Human exposure to RMA contaminants in groundwater is exceedingly small at this time. The most contaminated area, which is the emphasis of the interim action, is bounded approximately by Potomac Street to the east, the Arsenal Boundary to the south, and the O'Brian Canal to the northwest. This area will be referred to as Zone I of the site. In this area, contaminated groundwater is not used as a drinking water supply. The population in this area is approximately 100 people. The land use is largely dryland agriculture. Groundwater use is predominantly limited to watering livestock.

Contaminated groundwater in this area is believed to be migrating in a northwesterly direction where it would ultimately discharge to the South Platte River. This area, from downgradient of Zone I to the South Platte, will be referred to as Zone II. The current population of Zone II is approximately 400 people, including the Hazeltine subdivision. Some residents in Zone II use ground water as a drinking water supply. The South Adams County Water and Sanitation District (SACWSD) plans to develop a well field in Zone II, near Hazeltine. According to their projected demand, this water supply must be developed by 2015, though it may be developed earlier.

Although few, if any, residents currently use contaminated ground water as drinking water supply, such use is not prohibited. Population in these two zones is projected to increase at approximately 10% per year though 2010 (Little, 1987). New residents may use ground water as a drinking water supply, either from domestic wells or from the proposed new SACWSD well field.

The period of time between implementation of the interim action and the final remedial action is difficult to predict. For the purpose of this analysis, it is conservative to assume a longer duration, since the longer the period of exposure is assumed to be, the higher the time-integrated exposure and risk, thereby implying that more stringent ground water criteria for carcinogenic contaminants are appropriate. In this context, then, it is assumed that decisions made regarding the interim action will affect exposure to groundwater contaminants for an approximate 10-year period from 1990-2000. The year 2000 is the middle of the 30-year period (1985-2015) during which SACWSD intends to develop a well field in Hazeltine (SACWSD, 1985). It is assumed that either (a) the final remedial action will have had a significant effect on ground water, reducing exposure to negligible levels by the year 2000, or (b) the SACWSD-supplied water will be treated. Thus, even if the population at risk were using local groundwater as a drinking water supply, which it is not, the duration of exposure affected by the interim actions would be only 10 years. Then, if the individual lifetime cancer risk assuming 70 years of exposure is 10^{-4}, the actual lifetime cancer risk associated with consumption at that level for 10 years would be approximately 10^{-5}.

Based on the predicted rate of a 10-percent population growth in the area and the conservative assumption that this population will be supplied by local groundwater, the upper bound on the number of "people-years" of exposure can be calculated by :

$$\text{People-years} = \int_0^{10} P_o (1.10)^t dt = P_o \left. \frac{\exp(0.095t)}{0.095} \right|_{t=10} - \frac{1}{0.095}$$

Where P_o is the population in 1990, the assumed effective date of the interim action (approximately 800); and,

t is time in years after 1990.

Substituting P_o = 800, the maximum time integral of the population/duration of exposure is 13,400 people-years.

If the individual lifetime cancer risk resulting from exposure to the contaminants in the drinking water is less than 10^{-4} (assuming lifetime exposure), then the total number of excess cancer deaths expected in this population as a result of exposure to RMA-migrating contaminants during the effective period of the interim action would be less than [(people-years of exposure/70) x 10^{-4}], i.e. less than 0.02 for the entire population being considered. The numerical value implies that the odds are better than 50:1 that no cancer deaths within the exposed population would occur as a result of this exposure. Based on this analysis, it is concluded that the proposed criteria, based on 10^{-4} cancer risk, are protective of public health with an adequate margin of safety.

As a final, corroborative analysis, a method has been proposed by an EPA staff member (Milvey, 1986) to determine an acceptable risk level for small populations at risk. Milvey's formula for determining the acceptable risk, AR is given as:

$$AR = \frac{0.015}{P}$$

Using the maximum projected population in Zones I and II during the effective period of the interim action (i.e. 1,900 in the year 2000), the acceptable risk level would be 3.4 x 10^{-4}. The quantitative basis for Milvey's (1986) formula may be subject to debate, and there are convincing arguments against the proposition that high risks are acceptable for a small population at risk. Nonetheless, the formula tends to corroborate the establishment of 10^{-4} risk levels as the objectives of the interim action. The selected criteria will actually assure an individual lifetime excess cancer risk level of less than 10^{-5} for future ground water consumers. In summary, an interim action resulting in ground water quality for carcinogens at or below the nominal

10^{-4} risk levels is adequately protective of human health for the following reasons:

1. contaminated ground water is not currently used as a drinking water supply;
2. the interim action decision has the potential to affect exposure during, approximately, a 10-year period;
3. as a result, if anyone were to use the ground water as a drinking water supply during that period, their incremental cancer risk would not exceed 10^{-5}.

Thus, for those pollutants with ARARs, the recommended criteria will result in incremental cancer risks at or below the 10^{-6} risk level over the interim action period. As previously discussed, the criteria determined for contaminants for which no ARARs had been described will be protective of human health at a risk level of 10^{-5}. These risk levels are appropriate provided that the final action criteria will be protective of human health and welfare over a 70-year lifetime period.

Table 1. Data Priority for Health-Based Drinking Water Criteria*

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1. Final and proposed Recommended Maximum Contaminant Levels (RCMLs)

2. EPA Carcinogen Assessment Group (CAG) values

3. EPA Risk Reference Dose (RfD)/Superfund Public Health Evaluation Manual (SPHEM)

4. Health Assessment Documents (HAD)

5. Health Effects Assessment Documents (HEA)

6. Ambient Water Quality Criteria Documents (AWQC)

7. Health Advisory Values

8. World Health Organization (WHO) Guidelines

9. No-Observed-(Adverse)-Effect-Level (NOEL/NOAEL) with appropriate safety factors

10. Lowest Observed-(Adverse)-Effect-Level (LOEL/LOAEL) with appropriate safety factors

11. LD_{50} Median Incapacity Dose or Medium Lethal Dose using a safety factor to be established by USABRDL

12. EPA Guidance Levels

13. Threshold Limit Values (TLV)

14. Food & Drug Administration (FDA) Guidelines

*In the event that a state health standard or organoleptic value is more stringent than the above values, it shall take precedence. Should no standard be available, the concentration representing the 95% confidence interval background value [mean + 1.65 (standard deviation)] shall be designated as the criterion.

This priority list has been established to provide guidance in the selection of criteria designed to provide protection for offpost ground waters intended for drinking purposes.

Table 2. Recommended Criteria for RMA Offpost Ground Waters

		Health Based			Non-health Based				
Compound	Source	D_t Carcinogen (mg/kg/day)	D_t Noncarcinogen (mg/kg/day)	Ground Water Criteria (ug/L)	Alternate Source	Alternate Criteria (ug/L)	ARAR (ug/L)	Background Level (ug/L)+	RMA Criteria (ug/L)
Aldrin	EPA, 1986 SPHEM	$8.8x10^{-8}$		0.31 0.031 0.0031 0.00031			gps	<0.7 DL	0.31
Arsenic	SPHEM	$6.7x10^{-8}$		0.23 (50)* 0.023 0.0023 0.00023			MCL 50	5.0	5.0
Benzene	McGaughey, 1982 EPA, CAG	$3.4x10^{-5}$		120 12 1.2 0.12			PMCL** 5.0	2.5	5.0
Cadmium	EPA, 1985a FR50(219):46965		$5.1x10^{-4}$	18 (5)*	NIPDWS CDH domestic supply	10	PMCL 10	<5.2 DL	5
Calcium							NR	170,000	170,000
Carbon tetrachloride	SPHEM	$7.7x10^{-6}$		30 3.0 0.30 0.030			PMCL** 5	<2.4 DL	5.0
Chloride					NISDWS	250,000	NR	86,000	250,000
Chlorobenzene	EPA, 1985a FR50(219):47001		0.086	(60)* 3,000	AWQC OL Std FR45(231):79328	20	adj. AWQC 488	<0.58 DL	20
Chloroform	HAD, EPA ECAO, 1985b; SPHEM	$1.2x10^{-5}$		40 4.0 0.40 0.040			gps	<1.4 DL	40

Table 2. Recommended Criteria for RMA Offpost Ground Waters (Continued, Page 2 of 7)

		Health Based			Non-health Based				
Compound	Source	D_t Carcinogen (mg/kg/day)	D_t Noncarcinogen (mg/kg/day)	Ground Water Criteria (ug/L)	Alternate Source	Alternate Criteria (ug/L)	ARAR (ug/L)	Background Level (ug/L)+	RMA Criteria (ug/L)
PCPMS p-Chlorophenylmethyl sulfide	Thake et al, 1979 LOEL, subchronic		5.8×10^{-3}	200			gps	<1.3 DL	200
PCPMSO p-Chlorophenylmethyl sulfoxide	Thake et al, 1979 LOEL, subchronic		6.2×10^{-3}	220			gps	<4.2 DL	220
PCPMSO2 p-Chlorophenylmethyl sulfone	Thake et al, 1979 LOEL, subchronic		5.7×10^{-3}	200			gps	<4.7 DL	200
Chromium, Total	EPA, 1985a FR50(219):46966		4.9×10^{-3}	(120)* 170			Colorado MCL 50	<6.0 DL	50
Copper	SPHEM		0.037	1,300	CDH domestic supply CDH ag supply	1,000 200	adj. AWQC 1,000	<7.9 DL	200
DDT	SPHEM	2.9×10^{-6}		10 1.0 0.10 0.010			gps	<0.07 DL	10
DDE	Holder, 1986 EPA, CAG	2.9×10^{-6}		10 1.0 0.10 0.010			gps	<0.053 DL	10
Dibromochloropropane (DBCP)	EPA, 1985a FR50(219):46982	7.1×10^{-7}		2.5 0.25 0.025 0.0025	CDH requested level	0.2	gps	<0.13 DL	2.5
1,1-Dichloroethane	HEA, EPA OERR, 1984a		0.115	4,000			gps	<1.2 DL	4,000

Table 2. Recommended Criteria for RMA Offpost Ground Waters (Continued, Page 3 of 7)

Compound	Source	Health Based: D_t Carcinogen (mg/kg/day)	Health Based: D_t Noncarcinogen (mg/kg/day)	Health Based: Ground Water Criteria (ug/L)	Non-health Based: Alternate Source	Non-health Based: Alternate Criteria (ug/L)	ARAR (ug/L)	Background Level (ug/L)+	RMA Criteria (ug/L)
1,2-Dichloroethane	EPA, 1985a FR50(219):46883	1.09×10^{-5}		38 3.8 0.38 0.038			PMCL** 5	<0.61 DL	5.0
1,1-Dichloroethylene	EPA, 1984b FR49(114):24330		0.010	350			PMCL 7	<1.1 DL	7
1,2-Dichloroethylene	EPA, 1985a FR50(219):46991		0.010	(70)* 350			gps	<1.2 DL	350
Dicyclopentadiene (DCPD)	Dacre, 1984 NOEL		0.025	875	3 x 8 (OL threshold) CDH requested	24	gps	<9.31 DL	24
Dieldrin	SPHEM	3.3×10^{-8}		0.12 0.012 0.0012 0.00012			gps	<0.06	0.12
Diiospropylmethyl phosphonate (DIMP)	Marzulli, 1986 NOEL		0.75	26,300			gps	<10.5 DL	26,300
Dimethylmethyl phosphonate (DMMP)	Dunnick <u>et al</u>, 1983 LOEL		3.12×10^{-2}	1,090			gps	<15.2 DL	1,090
Dithiane	Schieferstein, 1986 LOEL		0.02	700			gps	<1.1 DL	700

Table 2. Recommended Criteria for RMA Offpost Ground Waters (Continued, Page 4 of 7)

	Health Based				Non-health Based				
Compound	Source	D_t Carcinogen (mg/kg/day)	D_t Noncarcinogen (mg/kg/day)	Ground Water Criteria (ug/L)	Alternate Source	Alternate Criteria (ug/L)	ARAR (ug/L)	Background Level (ug/L)+	RMA Criteria (ug/L)
Endrin	EPA, 1985a FR50(219):47011		$4.6x10^{-5}$	1.6	NIPDWS	0.2	MCL 0.2	0.074	0.2
Ethylbenzene	SPHEM		0.097	(680)* 3,400	3 x 100 (Taste threshold) FR50(219) 46595	300	adj. AWQC 2,400	<1.3 DL	300
Fluoride	EPA, 1985c FR50(220):47152		0.11	4,000	NISDWS FR50(220): 47156	2,000	BKGD 2,800	2,800	2,800
Hexachlorocyclopentadiene (HCCPD)					OL STD EPA, 1980 FR45(231):79336	1.0	AWQC 206	<0.07 DL	1.0
Isodrin	World Review of Pest Control, 1970		$7x10^{-5}$	2.5			gps	<0.06 DL	2.5
Lead	Health Advisory, EPA ODW, 1985d		$2x10^{-3}$	20^{++}			MCL 50	<18 DL	20
Magnesium							NR	32,000	32,000
Mercury, inorganic	EPA, 1985a FR50(219):46971		$1.57x10^{-4}$	(3)* 5.5	CDH Domestic Supply	2.0	Colorado MCL 2.0	<0.2 DL	2.0

Table 2. Recommended Criteria for RMA Offpost Ground Waters (Continued, Page 5 of 7)

		Health Based			Non-health Based				
Compound	Source	D_t Carcinogen (mg/kg/day)	D_t Noncarcinogen (mg/kg/day)	Ground Water Criteria (ug/L)	Alternate Source	Alternate Criteria (ug/L)	ARAR (ug/L)	Background Level (ug/L)+	RMA Criteria (ug/L)
Methylene chloride	HAD, EPA ECAO, 1985e; SPHEM		$1.3x10^{-4}$	4.7			gps	<5 DL	4.7
Methyl isobutyl ketone (MIBK)	EPA, 1986 CAG		0.05	1,750			gps	<12.9 DL	1,750
Nitrate			0.29	(10,000)*	NIPDWS	10,000	MCL 10,000	4,000 as N	4,000*** as N
Nitrite			0.029	(1,000)*			BKGD 4,000 as N	4,000 as N	4,000*** as N
Potassium							NR	3,700	3,700
Sodium	EPA Guidance Level FR50(219):46980		0.57	20,000			NR	140,000	140,000
Sulfate	EPA Guidance Level FR50(219):46979		11.4	400,000	EPA aesthetic guidance level FR50(219): 46971	250,000	NR	$1.7x10^6$	$1.7x10^6$
Tetrachloroethylene	SPHEM	$2.0x10^{-5}$		70 7.0 0.70 0.070			gps	<1.3 DL	70

Table 2. Recommended Criteria for RMA Offpost Ground Waters (Continued, Page 6 of 7)

	Health Based				Non-health Based				
Compound	Source	D_t Carcinogen (mg/kg/day)	D_t Noncarcinogen (mg/kg/day)	Ground Water Criteria (ug/L)	Alternate Source	Alternate Criteria (ug/L)	ARAR (ug/L)	Background Level (ug/L)+	RMA Criteria (ug/L)
Thioxane (1,4-oxathiane)	Mayhew and Muni, 1986 acute oral LD50		0.030	1,050			gps	<2 DL	1,050
Toluene	EPA, 1985a FR50(219):46981		0.29	(2,000)* 10,100	3 x 1,000 (odor threshold) EPA, 1985b FR50(219): 47005	3,000	AWQC 15,000	<1.21 DL	3,000
1,1,1-Trichloroethane	SPHEM		0.54	18,900			PMCL 200	<1.7 DL	200
1,1,2-Trichloroethane	SPHEM	1.7×10^{-5}		60 6.0 0.60 0.060			gps	<1.0 DL	60
Trichloroethylene	SPHEM	9.1×10^{-5}		320 32 3.2 0.32			PMCL** 5	<1.1 DL	5.0
Xylene	SPHEM		0.010	(440)* 350	3 x 300 (OL threshold) EPA, 1985b FR50(219): 47008	900	gps	<1.28 (m) <2.47 (o,p) DL	350

Table 2. Recommended Criteria for RMA Offpost Ground Waters (Continued, Page 7 of 7)

		Health Based			Non-health Based				
Compound	Source	D_t Carcinogen (mg/kg/day)	D_t Noncarcinogen (mg/kg/day)	Ground Water Criteria (ug/L)	Alternate Source	Alternate Criteria (ug/L)	ARAR (ug/L)	Background Level (ug/L)+	RMA Criteria *(ug/L)
Zinc	SPHEM		0.21	7,400	CDH domestic supply CDH ag supply	5,000 2,000	AWQC 5,000	26.8	2,000

*Signifies a PRMCL value.
+See text of letter for explanation of background levels.
**PMCL used because PRMCL and AWQC = 0.
++Based on a 10-kg child consuming 1L of water per day.
***Because nitrate and nitrite are analyzed as a single parameter, total N, the RMA criterion for each is set equal to the more stringent ARAR of 4,000 ug/L as total N.

Note: ARAR = acceptable or relevant and appropriate requirement.
SPHEM = Superfund Public Health Evaluation Manual.
gps = ground water protection standard.
(P)RMCL = (proposed) Recommended Maximum Contaminant Level.
(P)MCL = (proposed) Maximum Contaminant Level.
FR = Federal Register.
NIP(S)DWS = National Interim Primary (or Secondary) Drinking Water Standards.
CDH = State of Colorado Department of Health.
AWQC = Ambient Water Quality Criteria.
NR = Not required.
OERR = Office of Emergency and Remedial Response.
OL STD = organoleptic (taste and odor) standard.
HAD = Health Assessment Document.
HEA = Health Effects Assessment Document.
CAG = Carcinogen Assessment Group.
ECAO = Environmental Criteria and Assessment Office.
LOEL = Lowest-observed-effects-level.
NOEL = No-observed-effects-level.
BKGD = Background.

REFERENCES

Dacre, J.C. 1984. Recommended Interim Criteria for Three Environmental Polluting Compounds of Rocky Mountain Arsenal. Technical Report 8302, AD A154826. U.S. Army Bioengineering Research and Development Laboratory, Frederick, MD.

Dunnick, J.K., Harris, M.W., Gupta, B.N., Chapin, R.A., and Lamb, J.C. 1983. Reproductive Toxicity of Dimethyl Methylphosphonate (DMMP) in the Male Fischer 344 Rat. Toxicologist 3(1):19. (Abstract Only).

Holder, J. December 1986. Personal Communication; Telephone Conversation with Susan Robinson, Ebasco, re: Cancer Potency Factor for DDE. U.S. EPA Carcinogen Assessment Group, Washington, D.C.

Layton, D.W., Mallon, B.J., Rosenblatt, D.H., and Small, M.J. 1986. Deriving Allowable Daily Intakes for Systemic Toxicants Lacking Chronic Toxicity Data. Lawrence Livermore National Laboratory, Livermore, CA.

Little, J. 1987. Land Use Study for the Offpost Endangerment Assessment. A report by Reynolds, Smith & Hills transmitted by letter from James W. Little to William A. Tucker, June 10, 1987.

Marzulli, F.R. August 1986. Personal Communication; Memorandum to The Record re: Teleconference Review of the Standard for Diisopropyl Methylphosphonate (DIMP). National Research Council Committee on Toxicology, Washington, D.C.

Mayhew, D.A. and Muni, I.A. 1986. Dermal, Eye and Oral Toxicologic Evaluations: Phase II Report. Acute Oral LD_{50} Determinations of Benzothiazole, Dithiane, and Oxathiane. American Biogenics Corporation, Decatur, IL.

McGaughey, R. June, 1987. Personal Communication; Telephone Conversation with Alan Chandler, ESE, re: Cancer Potency Factor for Benzene. U.S. EPA Carcinogen Assessment Group, Washington, DC.

Thake, D.C., Mays, D., Leber, P., Metcalf, D., and Bavda, L. 1979. Mammalian Toxicological Evaluation of p-Chlorophenyl Methyl Sulfide, p-Chlorophenyl Methyl Sulfoxide, and p-Chlorophenyl Methyl Sulfone, Final Report, Contract No. DAMD 17-77-C-7038. Battelle Columbus Laboratories, Columbus, OH.

U.S. Environmental Protection Agency. 1979. Water Quality Criteria; Request for Comments. Federal Register 44(52): 15926-15981.

U.S. Environmental Protection Agency. 1980. Water Quality Criteria Documents; Availability. Federal Register 45(231): 79318-79379.

U.S. Environmental Protection Agency. 1984a. Health Effects Assessment Document for 1,1-Dichloroethane. Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency. 1984b. Federal Register 49(114): 24330.

U.S. Environmental Protection Agency. 1985a. National Primary Drinking Water Regulations; Synthetic Organic Chemicals, Inorganic Chemicals and Microorganisms; Proposed Rules. Federal Register 50(219): 46880-47022.

U.S. Environmental Protection Agency. 1985b. Health Assessment Document for Chloroform. Environmental Criteria and Assessment Office, Cincinnati, OH.

U.S. Environmental Protection Agency. 1985c. National Primary Drinking Water Regulations; Fluoride; Final Rule. Federal Register 50(220): 47156-47168.

U.S. Environmental Protection Agency. 1985d. Health Advisory for Lead. Office of Drinking Water, Washington, DC.

U.S. Environmental Protection Agency. 1985e. Health Assessment Document for Methylene Chloride; Addendum. Environmental Criteria and Assessment Office, Cincinnati, OH.

U.S. Environmental Protection Agency. 1986. Superfund Public Health Evaluation Manual. ICF, Inc. Washington, DC.

World Review of Pest Control 9:119. 1970. Oral LD_{50} Value for Isodrin. (Discontinued).